

## CLAIMS

1. A field emission type electron source device comprising:  
a field emission electron source portion including  
5 an extraction electrode provided on a p-type silicon  
substrate via an insulating film and having an opening  
portion at a position corresponding to a region where a  
cathode is provided; and a cathode portion provided on the  
p-type silicon substrate and at a position corresponding  
10 to the opening portion of the extraction electrode; and  
an n-channel field effect transistor portion  
provided on the p-type silicon substrate, corresponding to  
the field emission electron source portion,  
wherein:  
15 the field emission electron source portion is  
provided in a drain region of the field effect transistor  
portion; and a control voltage is applied to a gate electrode  
of the field effect transistor portion to control a field  
emission current from the field emission electron source  
20 portion;  
the drain region includes at least two wells having  
different impurity concentrations; and  
of the at least two wells, one well having a low  
impurity concentration is provided at an end of the drain  
25 region which contacts a channel region of the field effect  
transistor portion.
2. A field emission type electron source device according  
to claim 1, wherein as the impurity elements the drain region  
30 includes at least two n-type impurity elements having  
different thermal diffusion speeds in the silicon substrate.
3. A field emission type electron source device according

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to claim 1, wherein as the impurity elements, the drain region includes phosphorous, having a fast thermal diffusion speed and arsenic, having a slow thermal diffusion speed in the silicon substrate.

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4. A field emission type electron source device comprising:  
a field emission electron source portion including an extraction electrode provided on a p-type silicon substrate via an insulating film and having an opening portion at a position corresponding to a region where a cathode is provided; and a cathode portion provided on the p-type silicon substrate and at a position corresponding to the opening portion of the extraction electrode; and  
an n-channel field effect transistor portion provided on the p-type silicon substrate, corresponding to the field emission electron source portion,

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wherein:

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the field emission electron source portion is provided in a drain region of the field effect transistor portion; and a control voltage is applied to a gate electrode of the field effect transistor portion to control a field emission current from the field emission electron source portion;

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the gate electrode of the field effect transistor portion has a shape including portions having at least two different gate widths; and a part of the gate electrode is provided in such a manner as to cover an end of the drain region.

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5. A field emission type electron source device comprising:  
a field emission electron source portion including an extraction electrode provided on a p-type silicon substrate via a first insulating film and having an opening

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portion at a position corresponding to a region where a cathode is provided; and a cathode portion provided on the p-type silicon substrate and at a position corresponding to the opening portion of the extraction electrode; and

5 an n-channel field effect transistor portion provided on the p-type silicon substrate, corresponding to the field emission electron source portion,

wherein:

10 the field emission electron source portion is provided in a drain region of the field effect transistor portion; and a control voltage is applied to a gate electrode of the field effect transistor portion to control a field emission current from the field emission electron source portion;

15 a gate insulating film is provided between the gate electrode of the field effect transistor and the p-type silicon substrate; the gate insulating film includes a film thinner than the first insulating film, the first insulating film being provided between the extraction electrode and  
20 the p-type silicon substrate; and the gate insulating film is buried with the first insulating film.

6. A field emission type electron source device according to claim 5, wherein the gate insulating film includes a  
25 thermally oxidized silicon film, provided by a step of thermal oxidization for sharpening treatment for sharpening a tip of the cathode portion of the field emission electron source portion.

30 7. A field emission type electron source device comprising:  
a field emission electron source portion including  
an extraction electrode provided on a p-type silicon  
substrate via an insulating film and having an opening

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5 portion at a position corresponding to a region where a cathode is provided; and a cathode portion provided on the p-type silicon substrate and at a position corresponding to the opening portion of the extraction electrode; and an n-channel field effect transistor portion provided on the p-type silicon substrate, corresponding to the field emission electron source portion,

wherein:

10 the field emission electron source portion is provided in a drain region of the field effect transistor portion; and a control voltage is applied to a gate electrode of the field effect transistor portion to control a field emission current from the field emission electron source portion;

15 the field emission type electron source device further comprises a shield electrode made of the same material of that of the gate electrode of the field effect transistor portion, and the shield electrode is provided in such a manner as to cover a channel region of the field  
20 effect transistor portion which is not covered with the gate electrode.

8. A field emission type electron source device according to claim 7, wherein the shield electrode is held at the same  
25 potential as that of the p-type silicon substrate, and the shield electrode has a function of blocking an external field, which is not caused by the gate electrode, from affecting the channel region.

30 9. A field emission type electron source device comprising:  
a field emission electron source portion including an extraction electrode provided on a p-type silicon substrate via an insulating film and having an opening

portion at a position corresponding to a region where a cathode is provided; and a cathode portion provided on the p-type silicon substrate and at a position corresponding to the opening portion of the extraction electrode; and

5           an n-channel field effect transistor portion provided on the p-type silicon substrate, corresponding to the field emission electron source portion,

wherein:

10           the field emission electron source portion is provided in a drain region of the field effect transistor portion; and a control voltage is applied to a gate electrode of the field effect transistor portion to control a field emission current from the field emission electron source portion;

15           the drain region of the field effect transistor portion is provided in a source region of the field effect transistor portion in such a way to be surrounded by the source region; and

20           the gate electrode of the field effect transistor portion is positioned symmetrical in a plane with respect to the cathode portion of the field emission electron source portion.

25           10. A field emission type electron source device according to claim 9, wherein the drain region includes a p-type conductive layer.

30           11. A field emission type electron source device according to claim 9, wherein an outer portion of the drain region contacts the channel region of the field effect transistor portion; and the outer region of the drain region and an inner portion of the source region have a shape of concentric circles.

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12. A field emission type electron source device according to claim 9, wherein at least a part of the gate electrode provided between the source region and the drain region has  
5 a shape of a symmetrical circular arc.

13. A field emission type electron source device according to claim 9, wherein first voltage  $V_{ex}$  applied to the extraction electrode of the field emission electron source  
10 portion and second voltage  $V_g$  applied to the gate electrode of the field effect transistor portion have a relationship such that  $V_g < V_{ex}$ .

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